Feature Repurposing and Cognitive Efficiency in Financial Trading Systems

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Abstract

Many IS research domains such as cognitive fit and information overload assume that the user selects from a fixed menu of IS features to accomplish goals. IS pliability researchers offer a new perspective by recognizing the users' discretion in altering or creating new features. While this IS pliability research has important implications, it is currently descriptive rather than explanatory. To explore IS pliability in the form of causal propositions, we examine data from a Fortune 1000 brokerage firm where some traders created what the IS developers considered superfluous "extra" accounts. Levering insights from the referent theory of cognitive niche construction, we propose that these multiple accounts align the representation of information presented with the users' conceptual trading strategies. This alignment in turn facilitates trading research through the reduction of task switching and the learning benefits supported by category labels. The empirical analysis is consistent with these propositions.

Keywords: Feature repurposing, IS pliability, Cognitive Niche Construction, Concepts

Introduction

The growing presence of information systems (IS) in all aspects of life calls for the development of a new understanding of the user-IS relationship (Vodanovich et al. 2010). A defining characteristic of this evolving user-IS relationship is the users' sophistication with the use of the IS. Individuals in many cultures have worked with some form of IS for decades and are consequently not intimidated by but rather comfortable with manipulating the IS artifacts. This manipulation includes a cleverness in extending the use of the artifact beyond its designed affordances. The imbuing of IS with such "pliable" features has drawn considerable IS researcher attention: "In many modern organizations it may be as easy for people to change the material makeup of a technology, and hence its material agency, as it is for them to change existing routines" (Leonardi 2011, p. 149); "people can be forced by external triggers… to engage in adaptation cycles during which they actively revise their system use in order to achieve a better fit between the system and the context in which they are using it" (Sun 2012, p. 453-454). In short, just as individuals take creative license with physical tools, such as using a hammer as a paper weight, today's users seek to manipulate IS in a manner not necessarily anticipated by the IS designers in order to better perform their tasks or perform new tasks in an act termed "feature repurposing" (Sun 2012). This topic remains "little studied and even less well understood" (Leonardi 2011) and requires continued evaluation (Kallinikos et al. 2013).

One consequence of this growing IS presence is the exponential growth of digital information as users rely on IS in professional, social, and personal settings. Consider only one facet of this IS prevalence - the emergence of online self-service (Lambert 2015). In a typical day, an individual might make travel reservations, select a utility provider, and conduct financial transactions through a smart phone or tablet. In planning only for the travel arrangements of a family vacation, users might collect and evaluate information concerning prices, times, dates, baggage fees, refund options, reward points, on-time reliability as provided by a government agency, and complaints as shared by peer travelers through social

media. For the selection of a utility service, users might compare across candidate providers billing options such as flat or seasonal rates, flexible payment dates, varying commitment length, termination fees, temporary promotions, and enrollment discounts. Online brokerage firms, the setting for this research, support for expert and novice users alike the ability to trade exotic securities that in turn may call for the user to assemble and assess information concerning risks, historical performance, portfolio implications, and tax consequences. As evidenced by users' struggles to simply manage passwords across systems, managing this information is a challenge.

Our research interest is the relationship between these two consequences of IS prevalence – does feature repurposing address information processing and if so, how? While extant IS pliability researchers provide rich descriptive observations as well as nuanced observations of pliability equivocality, this research is of limited use in developing propositional claims between systematic user behaviors and outcomes. A related gap is found in the IS research regarding cognitive effort, such as cognitive fit (Vessey 1991), that does not recognize the users' agency in altering the artifact features.

Our research challenge is thus to discover an information-intensive setting with identifiable instances of feature repurposing, identify theory to inform our understanding of the feature repurposing behaviors, and posit consequences of these behaviors. We were presented the opportunity to uncover such a setting in a Fortune 1000 online brokerage firm where retail traders are provided extensive sources of research information to use in making trading decisions. The organization's analytics staff discovered that some traders were creating what from the perspective of the IS developers were superfluous accounts. These "additional" accounts were not anticipated by the system developers and were not explicitly accommodated by the IS and are thus by definition a form of feature repurposing.

To understand the motivation and consequences of the creation of these "superfluous" accounts in terms of managing immense volumes of information, we turn to the referent theory of distributed cognition (Kirsh 2010) where actors leverage the environment for cognitive support. Specifically, we examine distributed cognition in terms of cognitive niche construction, defined as environmental manipulation enacted to facilitate later task execution, "…a pervasive, though widely underestimated, force in nature. All animals act on their environments and, in so doing, alter those environments in ways that may sometimes change the fitness landscape of the animal itself" (Clark 2011, p. 61). As we elaborate in the theory section, we propose that this niche construction behavior can be understood in terms of mental structures in the form of concepts, the core units of thought (Carey 2009; Cohen and Lefebvre 2017) through which we derive maximum information with the least cognitive effort (Rosch 1999; Levitin 2014) to direct our behavior (Harnad 2017). This organization of securities by account aligns the properties of the subcollections of financial securities with the abstract mental structures guiding the analysis and decision-making for research and trading. As a result, the user can serially process trades by concept and minimize the cognitively demanding act of task switching. We offer two hypotheses into the consequences of this organization. First, we posit that those managing trades through multiple accounts will be more efficient in researching trades. Secondly, as the creation of categories enhances the understanding of concepts (Murphy 2002), we posit that the benefits of this categorization increases with use. Using security trader attributes and trading activities data representing more than two years of trading for over 4,000 clients, we find the empirical results are consistent with these hypotheses.

We seek to contribute to the user-IS relationship research by identifying normative rather than descriptive or equivocal feature repurposing behaviors (Sun 2012). Specifically, the relationship between feature repurposing and cognitive effort. Extant feature repurposing is descriptive. Related IS research regarding cognitive effort such as cognitive fit afford the users no discretion with features. Insight into such behaviors may offer important extensions for several IS research domains. For instance, both cognitive fit research (Vessey 1991) and IS information overload research implicitly treat the IS artifact features as static and exogenous to the user. For the cognitive fit research, user agency is constrained to the selection of predefined options and thus efficacy capped as "correct" or "incorrect." Information overload research is limited to examining the user affect, such as disengaging (Jones et al. 2004) and delegating (Farhoomand and Drury 2002), or to the designer enhancements, such as recommendation services (Xiao and Benbasat 2007). Accounting for IS malleability and understanding the user behaviors in terms of aligning mental structures to physical features allows for new approaches for these domains to evaluate the relationships and outcomes.

We also aim to contribute to the distributed cognition research by examining the users' organization of digital representations of abstract concepts rather than the users' organization of concrete objects representing natural categories, such as the sorting of vegetables to sauté (Storms, Navarro, and Lee 2010). In addition, while some cognitive science research regarding the organization of information relies on technology as a medium, such as simulations of common objects (Neth and Paynem 2011; Solman and Kingstone 2016), the technology artifact as an explanatory factor in categorization formation and use has not been explored.

In the following research setting section, we describe the data collected, the variables representing the research constructs, and review how we address the modeling challenges presented by the data. We offer this description in advance of the theory section to allow more meaningful references to the context when discussing theory. In the following theory section, we explore how the use of niche construction as a referent theory opens the examination of feature repurposing as a normative act of alignment between cognitive processing and the organization of information. We then examine feature repurposing as the arrangement of information in alignment with the users' concepts and thus reducing the need for task-switching, a cognitively demanding act. We follow with the findings. In the discussion section we review research limitations, propose research extensions, and conclude by connecting this research to additional real-world phenomena.

Research Setting

Our research setting is a Fortune 1000 online brokerage firm supporting active traders who are confronted with numerous and continuous sources of information, characteristic of the overwhelming growth of information discussed in the introduction. The brokerage IS features include transaction execution, research support, and account management. The transaction features include support for buying and selling bonds and other fixed income securities, exchanged-traded funds and mutual funds, currency trading, futures, options, and individual company stocks.

The IS research features include the provision of information on stock fundamentals and economic measures, watch lists, social media monitoring metrics, news, and third-party research that together inform the traders' actions. Traders may have a variety of strategies for trading. Some traders may rely upon technical analysis, through which future values are anticipated through the analysis of the movement of historical prices. Some traders may rely upon financial analysis, incorporating news into the financial condition of the security to anticipate future value. Many other trading strategies are employed.

The account management features allow the creation and management of multiple accounts to create trusts (to be associated with a legally established trust), business (e.g., limited partnerships, partnerships, limited liability, sole proprietorship), retirement, education, guardianship, investment clubs, and individual (post-tax) accounts to support regulatory requirements. For instance, trades executed using after-tax funds need to be separated from those trades using pre-tax retirement funds, health savings funds, or individual retirement account funds. Thus, traders are allowed to create multiple accounts supporting the adherence to such legal requirements. Through these accounts, traders place trades for a variety of securities.

For no reason evident to the brokerage firm, some traders created multiple individual after-tax accounts. The creation of these accounts serves no regulatory purpose nor does it serve any practical purpose with respect to the functionality of the IS with respect to transactions, research, or account management. These multiple accounts are by definition an instance of feature repurposing as the multiple accounts do not support any function as intended by the platform designers. These accounts likewise exhibit the characteristics of niche construction in that the creation of multiple accounts does not serve any direct, pragmatic function and the accounts persist across time.

In the next section, we propose that the creation of these multiple accounts align with the traders' conceptualization of their securities and through this organization, traders' more efficiently research subsets of securities and execute trades. For instance, a trader may have segmented securities that represent theory categories such as "stocks that are more volatile to economic trends," "options that will vary in value as executive leadership changes," and "utility stocks with values that vary with changes in the LIBOR." Similarly, a trader may have segmented securities by goal-oriented concepts, such as high-risk accounts, college savings accounts, and retirement accounts, each which require a different approach

to research and trading. To the degree that such separation may be associated with different trading behaviours, we would expect that such an organization results in reduced cognitive effort.

Theory

Feature Repurposing for Cognitive Fit

Cognitive fit research (Vessey 1991) establishes the benefits to matching the properties of information with the demands of a task. For instance, as graphs represent information spatially as opposed to symbolically, tasks that call for the analysis of relationships are better addressed through the use of graphs than through the use of tables. In extant cognitive fit research, the selection among a fixed menu of options provided by the artifact designer and developer is the extent of the user's discretion. However, IS researchers have more recently explored IT artifact material properties as endogenous to the user. One example of this new perspective is feature repurposing[1], defined as using IS features in a manner not necessarily intended by the IS designers (Sun 2012) with features defined as the functional building blocks of IS that correspond to tasks that the IS is designed to support. Including this feature repurposing perspective in the context of cognitive fit provides new opportunities to include the user's agency with respect to achieving cognitive fit.

However, feature repurposing has been examined for descriptive rather than evaluative purposes in order to avoid normative value judgments concerning "better" uses (Sun 2012). To extend feature repurposing to allow for a normative evaluation consistent with the findings of cognitive fit, we examine feature repurposing as a form of distributed cognition, where actors leverage the environment to facilitate cognition (Hollan, Hutchins, and Kirsch 2000). Through distributed cognition, agents conserve effort, a fundamental motivation assumed across the social sciences (Kool, McGuire, Rosen, and Botvinick 2010).

We examine feature repurposing in the context of distributed cognition as an epistemic effort, that is, a manipulation of the external world that does not directly advance progress towards a goal but facilitates the execution of subsequent tasks, to "change the world in order to simplify the problem-solving task" (Kirsh and Maglio 1994). Examples of epistemic action include the arrangement of letters in the board game Scrabble that allows for the easier identification of word candidates, the rotation of shapes in Tetris to better anticipate shape fits (Kirsh and Maglio 1994), and the organization of work spaces such as organizing ingredients by order of recipe tasks (Kirsh 1995) or organizing coins by value to ease summing (Neth and Payne 2011).

These examples of epistemic action represent efforts transitory in nature, enacted to facilitate a specific goal – winning a specific game, preparing a specific dinner, and completing a specific puzzle. Enduring epistemic efforts that facilitate recurring pragmatic tasks have been examined through the ecological construct of niche construction (e.g., Clark 2011). Niche construction extends the construct of niche, defined as the "…joint description of environmental conditions that allow a species to satisfy its minimum requirements so that the birth rate of a local population is equal to or greater than its death rate along with the set of per capita effects of that species on these environmental conditions" (Chase and Leibold 2001, p. 16). Niche construction is a distinct ecological concept in which the environment is examined as endogenous rather than exogenous to the actors, "Rather than acting as an 'enforcer' of natural selection… the environment will be viewed here as changing and coevolving with the organisms on which it acts selectively" (Odling-Smee et al. 2003, p. 2) with "…the dynamical products of a two-way process involving organisms both responding to their environments and changing their environments" (p. 240). While niche construction as used in ecology concerns intergenerational alterations and is not necessarily intentional or even beneficial (Scott-Phillips et al. 2014), application of niche construction in the cognitive sciences (e.g., Clark 2011) examines how actors proactively alter the environment to support ongoing

[1] Sun (2012) identifies constructs with similar meanings such as unanticipated use (Singletary et al. 2002), feature extension (Jasperson et al. 2005), exaptation (Desouza et al. 2007); Kallinikos et al. (2013) identify flexible standards (Hanseth and Lyytinen 2010), function-agnostic interfaces (Yoo et al. 2010), intentionally incomplete technologies (Garud et al. 2008; Zittrain 2008); Schmitt et al. (2016) offer the term malleable IT and draw parallels to terms used by Kallinikos et al. (2013) such as editable, fluid, interactive, open, reprogrammable, pliable, and transfigurable.

cognitive tasks. Niche construction serves as a framework that extends our understanding of active agency in leveraging environmental resources to enhance and amplify cognition (Sterelny 2010). What distinguishes epistemic actions from niche construction is that the former addresses immediate goals through transitory manipulations while niche construction alters the fitness landscape producing enduring change.

Our research interest is understanding user approaches to feature repurposing as a form of niche construction, through which users achieve a cognitive fit between task attributes and cognitive demand, thereby conserving cognitive effort.

Niche Construction Enacted in Support of Task Switching and Category Labels

The gains to be achieved from distributed cognition in general include conservation of working memory, identification of new operators to apply towards analysis, the creation of persistent references, the anchoring of mental processes to external features, the teasing out of consequences of action, and the creation of "objects of thought" through which the actor better grasps the referent (Kirsh 2010).

Our interest is the actor's feature repurposing as a form of distributed cognition to create the persistent organization of external objects aligned with the actor's conceptualization of a set of tasks to be performed upon the objects. We examine these sets of tasks through the cognitive lens of concepts, the innate manner actors organize knowledge of the world internally and through this organization reduce cognitive effort (Rosch 1999). Concepts[2], as part of an overall schema of understanding (Murphy 2002), serve as an input to mental activities (Barsalou 2003) to allow actors to make sense of the world through analogy – extending existing knowledge to newly classified instances and inferring further attributes and behaviors of these instances (Rips et al. 2012; Murphy and Medin 1985).

Concepts were originally studied through predefined attributes of similarity (initially through rule matching and later through prototypes and exemplars) of tangible objects experienced through the senses. However, cognitive scientists now recognize a broader definition of concepts with subjective boundaries applied to intangible entities. These unsupervised concepts may concern subject matter such as roles (Goldwater and Markman 2011; Markman and Stillwell 2001), goals (Barsalou 1985), themes (Lin and Murphy 2001), theories (e.g., a person jumping in pool with clothes is drunk (Murphy and Medin 1985)), and ad hoc relationships (Barsalou 1982; Barsalou 1983) such as "things that I need to save from a fire" (Levitin 2014). The formation of such concepts allows for purposeful action, directing attention to relevant cues and invoking pertinent actions.

An actor's organization of informational cues by goal or theory concept to facilitate cognition has been recognized among cognitive scientists through spatial arrangements, such as sorting parts in planning the assembly of toys or sorting recipe ingredients by those that need to be chopped, those that need to be washed, and those that need no preparation (Kirsh and Maglio 1994). Though this initial categorization is performed at a cost, the cost is often less than that of analyzing and acting ingredient by ingredient. Following this understanding, author and neurologist Oliver Sacks recommends employing two desks when working on two distinct projects (Levitin 2014, p. 92).

The cost calculus of this serial application of actions can be described in terms of suspending and activating goal states referred to as task switching. Efficiency and effectiveness decline when actors switch between sets of operations and the related goals addressed by the operation sets (American Psychological Association 2017; Monsell 2003; Ravizza and Carter 2008). Concepts specifically have been represented as information structures with features manifest in the form of parameters of "slots" (Barrett 2015). As actors cycle through different concepts, these slots needs to be refreshed and reset. This performance degradation has been examined as a biological phenomenon, with task switching resulting in a higher consumption of oxygenated glucose in the brain, thus tiring actors more quickly than had the tasks been "single threaded" (Goldhill 2016) and modeled as well (Altmann and Gray 2008). Task switching can take a number of forms, such as multiple concurrent demands that require "scheduling" of cognitive effort,

[2] The terms concepts and categories are used inconsistently among researchers (Murphy, 2002, p. 5). In this paper, category refers to the material environment, concept to a summarized mental representation of a category, and categorization to the assignment of an instance in the environment to a concept.

interruptions that require mental reconstructions of prior states, or the suspension and activation of subgoals based upon presented cues.

We propose that one form of IS feature repurposing is the organization of the environment that supports the serial evocation of goal-based concepts and the avoidance of task switching. Those actors who repurpose under this condition will process tasks more efficiently. Specifically, we hypothesize:

H1: Traders with multiple accounts will spend less time researching per trade

The study of categories typically concerns the choice of the categorization of an instance as the outcome variable and would benefit from understanding outcomes in terms of performance related to the learning that comes from concept formation (Murphy 2002). While the first hypotheses identifies the value in the organization of information through aligning accounts with trading strategy concepts, value may also be realized simply through the creation of a "new identity" serving as a conceptual "anchor" (Clark, 1997) and "embodiment of our theories" (Gelman and Coley 1991, p. 190), making abstract ideas available for inspection (Clark and Karmiloff-Smith, 1993). This benefit has been studied through the "label" assigned to the category. The presence of labels results in faster learning (related to categorization) even though the labels do not provide additional information (Lupyan 2006). We hypothesize that the creation of subaccounts will further benefit the traders' research evaluation through use – with each trade the nature of the category becomes clearer and more meaningful to the trader, allowing more efficient information processing.

H2: Traders with multiple accounts will spend decreasing time researching per trade as they gain experience trading.

Empirical Analysis

Data and Analytic Approach

The brokerage firm's analytics staff maintains a set of transaction and master tables that include client profiles, trade activities, security attributes, and platform-specific browsing activities. The data analyzed in this research is sourced from these tables. The data collected represents trading and research activity over a period 125 weeks for those traders with after-tax accounts who used the firm's research platform. Certain types of accounts, such as IRAs, present constraints on trading activity that may indirectly influence how traders are able to organize their after-tax accounts. Consequently, we include in the data only those traders who own only after-tax individual trading accounts.

Our data set consists of 4,043 traders who collectively performed 82,582 trades over a 125 week period. Of these traders, about 11% had multiple after-tax accounts and represent about 11% of the trades. Traders are evaluated as single or multiple account holders on each date of a trade. If a trader with two accounts closed one of the two accounts during the trading period evaluated, the trader would on that date be classified as a single account classification. Traders who opened and closed multiple after-tax trading accounts without any chronological overlap between the accounts are treated as single account holders. The account holders traded a broad range of security types and represent, in general, an experienced set of traders, a benefit for our research in that the abstract theory or goal concepts are more likely to be employed by actors experienced in a particular domain (Chi et al. 1981; Murphy 2002, p. 232-233). Descriptive statistics of the traders are provided in Table 1.

Table 1. Averages and Standard Deviations (parentheses) of Trader Attributes

Attribute	Overall	Multiple Account Holder	Single Account Holders
Age (years)	56 (15.6)	61.0 (16.6)	55.6 (15.4)
Tenure (years)	9.7 (6)	11.3 (5.8)	9.5 (6)
Experience (trades)	509 (1042)	424(449)	521 (1099)

Wealth (US dollars)	1,406,076 (2,922,816)	2,853,163 (5,616,452)	1,205,070 (2,239,858)

Table 1. Averages and Standard Deviations (parentheses) of Trader Attributes (at the start of data collection)

There are several characteristics of the context and thus the data collected that inform the model we develop. First, the unit of analysis, the trader research time, is not independent and identically distributed (IID) across trades. Rather, research and trades executed by the same trader across time will reflect common influences of the specific trader resulting in correlated error terms, a state of unobserved heterogeneity. We thus employ a hierarchical or mixed model, with the trades "nested" within the individual trader. The trader serves as a categorical, random effect variable allowing for the recognition of differences across traders. While the term random is not used consistently across statistical analyses (Kreft and de Leeuw 1998)), in our case the random effect allows the modeling of a random intercept to address the "nesting" and thus IID violation. Mixed models also accommodate uneven time periods, unlike many econometric panel data techniques, consistent with the trader behavior. The mixed model thus allows for traders to have distinct, individual levels of performance for research time. As traders may learn at different rates as well, a random slope is also added based on tenure to accommodate these individual differences, thus resulting in unbiased variable coefficients.

Second, the research time is strictly bound at zero and right skewed thus not characteristic of a Gaussian distribution assumed by standard mixed-model (Gurka et al. 2005). To accommodate the distribution of the dependent variable research time, we examine both a dependent variable transformation and a generalized mixed model with a link function. The data as longitudinal may exhibit correlation across time periods. Accordingly, we examine different variance-covariance matrices sensitive to autocorrelation applied to the mixed model as explained in the Findings section.

Third, we must address trader self-selection across "types" – the single account holder and the multiple account holder. The data collection setting can be characterized as a quasi-experiment (Cook and Campbell 1979) in that the traders can be grouped as a treatment (multiple account holders) and control (single account holders). However, traders are not randomly assigned across the two types. Rather, the traders choose whether to create multiple accounts. This begs the question as to why all traders don't employ multiple accounts? One explanation for the single account holders is that some traders have a single theory or goal concept across all securities so a single account is sufficient. If this is the only explanation for the difference between traders with multiple accounts and those with a single account, no differences will be found across treatment and control types in the empirical analysis. A second reason for the single account holders is that actors exhibit innate variation in inclinations for organization as reflected in measured differences in conscientiousness (Levin 2014). Some people have orderly desks and clean cars, others do not and this order can influence efficiency. Actors may also have different "metacognitive beliefs" as to whether performing such actions are beneficial and act accordingly (Dunn and Risko 2016). If the account creation is simply an accounting convenience, no differences will be found across trader types.

Self-selection is a concern in that those traders who organize their securities by multiple accounts may also be more efficient in conducting trades. Thus, rather than niche construction enabling improved performance, actors with certain qualities may both organize their environment differently and expend mental effort more efficiently. We address self-selection concerns through two distinct approaches. We first use group matching (Rosenbaum and Rubin 1983). Through this approach, subjects are "paired" across treatment and control using attributes that allow for similarity comparisons. The resulting data consists of similar subjects across treatment and control and thus the treatment and control groups can effectively be compared.

Matching techniques are only as applicable as the variables selected to match are related to the cause of separation (Tucker 2010), a condition of "ignorability" (Rubin 1978) where the data can be treated as randomized conditioned upon the matching covariates. In many research settings, the candidate variables employed for matching are not the source for separation, they are proxies for the causes, and thus are imperfect measures. Given the numerous contextual attributes that may affect our model's error terms as discussed above, we employ a form of generalized method of moments (GMM) estimator that maintains the benefits of the mixed model error term correction (Kim and Frees 2007). GMM can be considered a

more general framework that includes standard instrumental variable techniques (Hansen 1982) provided it is used with large data sets (Hayashi 2000). In the present analysis, GMM provides the benefits of no distribution assumptions and robustness to heteroscedasticity. Such qualities, particularly the lack of distributional assumptions, have made GMM a popular estimator in finance (e.g., Cochrane 2005).

Model Variables

We use the actors' time spent researching per trade as the dependent variable. Elapsed time is a commonly used outcome measure in cognitive science and related IS research (e.g., Xiao and Benbasat 2007) and serves as a proxy for effort. Evaluating outcomes in terms of financial return is problematic as the financial trading context is a zero-validity task environment, that is, unpredictable with unstable relationship between cues and returns (Kahneman 2011; Kahneman and Klein 2009; Shanteau 1992).

The independent "treatment" variable is the ownership of multiple accounts. We propose that those traders with multiple after-tax accounts will on average spend less time researching per trade compared to those traders with a single after-tax account, with the ownership of a single account or multiple accounts represented as a categorical binary value by the date of trade. We further propose that the creation of multiple accounts facilitates learning of the concepts so we would expect experience as an interaction with treatment to also be associated with reduced research time.

We include four control variables. Tenure is measured as time elapsed between joining the brokerage platform as a member and the day of a trade and experience as the number of trades executed starting from the beginning of the study. Tenure and experience are included in recognition of the learning curve relationship between performance and experience (e.g., Teplitz, 1991). We expect that research time per trade will decline as traders gain general experience. Trader age and wealth are both attributes that may influence the rigor of research. More wealth at risk may inspire more research. Older clients, as they become more dependent upon their securities holdings as a source of income, may likewise spend more time researching. The research intensity may diminish at the extremes; for instance, a very wealthy, elderly trader or a young trader with little invested have less at risk, thus we examine the variables as polynomials in the model.

The matching method requires measures to allow for the pairing across treatment and control. The matching variables should ideally represent the reason for the separation of the traders between treatment and control subjects. One reason for the creation of multiple accounts above and beyond the hypothesized benefits of task-switching reduction may be the complexity of the traders' strategies. More complex trading behavior may be associated with more elaborate behavior in general, including the creation of multiple accounts, but would not necessarily lead to shorter research times. In fact, greater trading strategy complexity may lead to more research effort.

We generate two measures to capture complex trading behaviors: variability and entropy. We measure variability as the variance in the number of trades executed across the entire data collection period. The more variation in trading patterns would not necessarily reflect in greater duration of research time per trade but may indicate more production rule sets and thus inspire the creation of multiple accounts. We measure entropy as the predictability of trading behavior in terms of information-theoretic measures. The greater the complexity, the higher the measure of "randomness." We measure this randomness by capturing the pattern of trading days and non-trading days across the entire study as a sequence of binary values (trade or no trade). The resulting pattern is then measured in terms of Shannon entropy (Shannon 1948) which in the present case is simply the proportion of trades and no trades, with a perfect balance translating to pure randomness. Specifically, Shannon entropy is calculated as the sum of the probabilities of each class multiplied by the log of the inverse of the probability of each class.

We introduce a complementary, second measure for entropy via a random length encoding (RLE) measure in which each change from the previous state (trade or no trade) is counted, similar in purpose to Kolmogorov complexity, a measure of the minimum information required to describe the pattern. The following contrasting four examples will illustrate the two measures. One trader's trades across thirty trading days are captured as a string "000000000000000011111111111111" which translates to an RLE value of 2 and a Shannon entropy value of 1. The second trader's trading sequence "100011001011111000000101001111" has an RLE value of 13 and a Shannon measure of 1. A trading sequence of "000000000000000000000000000001" for the third trader has a RLE value of 2 and a

Shannon entropy value of .21. The fourth trader's trading sequence "00000000000000000000001111111111" has an RLE value of 2 and Shannon entropy value of .91. Higher values suggest greater randomness. We propose that the greater the randomness, the more nuanced on average are the traders' concepts as this unpredictability suggests criteria met to trigger a trade which in turn suggests either more criteria to evaluate or more subtle ways of processing information. While sophisticated concepts may be applied by those that trade daily producing a "simple" timing patter, the continuous trader may also be one that has simple rules and thus the lower values represent a mix. The less predictable scores represent a more consistent complex approach.

Table 2 provides a summary description of the model variables.

Table 2. Model Variables	
Dependent Variable	
Research Time per Trade	Web browsing time on research pages within broker online trading platform divided by the number of trades conducted over the same time period
Independent Variables	
Treatment	Trader possesses multiple after-tax accounts
Experience by Treatment	Interaction between experience and treatment
Matching Variables	
Trade Variation	Variation in the number of trades executed daily
Timing Complexity	Summarized pattern of trades across research time period
Control Variables	
Tenure	Time elapsed since the trader joined open the first account on date of trade
Wealth	The amount at stake may influence the duration of research
Experience	Number of cumulative trades on date of trade from start of study
Age	Age at time of trade
Random Effect Variables	
Trader Identity	Identification of specific trader

Table 2. Model Variables

Findings

The correlations between the continuous variables are presented in Table 3. We use AIC as a criterion for comparison across models in testing polynomials for age and wealth and find that while modeling age quadratically provides the best fit, wealth is better modeled linearly.

Table 3. Variable Correlation				
	Tenure	Wealth	Age	Experience
Tenure	-			
Wealth	0.087	-		
Age	0.302	0.200	-	
Experience	0.074	0.080	0.143	-

Average Research Time	-0.016	-0.027	0.002	-0.051

Table 3. Variable Correlation

Model 1

We match data through the MatchIt package in R (Ho et al. 2011) using nonparametric matching methods (Ho et al. 2007) thus producing more robust inferences when a parametric model is used for the resulting data analysis. We examine several matching parameters that each produce similar results, ultimately selecting a nearest neighbor match using a logit distance between traders. The matching algorithm generates a propensity score of the probability of being classified as "treatment" based upon the accompanying covariates, allowing each control (the more prevalent condition) to be matched multiple times with a treatment client to assure closer comparisons. The matching algorithm randomly selects candidates to pair if more than one is available. After the pairing is performed using the matching variables described in Table 2, the data set is reduced to 2,100 unique traders conducting 24,248 trades representing an equal proportion of treatment and control cases.

We use this matched data with a mixed model (with trades "nested" within clients) as implemented in the nlme package in the statistical software R (Pinheiro et al. 2016) using log transformation to address the extreme valued distribution characteristic of the data. We attempt to account for autocorrelation via several variations of variance-covariance matrix forms, comparing across the forms the Akaike information criterion (AIC) values (using the maximum likelihood estimation methods rather than restricted maximum likelihood estimation used to report the results to allow for model comparisons (Pinheiro and Bates 2000)). A model with an autocorrelation structure of order one and a continuous time covariate provided the best results.

Model 2

For our GMM estimator we use the REndo package (Gui et al. 2017). This approach covers the unignorable treatment condition, that is, no direct measure of the cause for the separation into treatment and control is available. The REndo package, by exploiting the hierarchical modeling of the data, does not require the additional specification of a set of instrumental variables but instead builds "internal" instruments (Kim and Frees 2007). We use an inverse Gaussian transformation for the dependent variable of research time.

Results

The results for the models are presented in Table 4.

Table 4. Model Results for Average Research Time per Trade		
Variables	Matching Model	GMM Model
Treatment	-0.3730(0.10)***	-0.21(0.06)**
Experience * Treatment	-0.0002(0.0001)·	-0.0003 (0.00009)**
Tenure (days)	-0.0226(0.008)*	-0.04 (0.005)***
Wealth (thousands)	0.00004 (0.00002)**	-0.00002(0.0000)
Age (days)	-19.91(7.01)**	-13.64(4.95)**
Age^2 (days)	73.66(22.77)**	53.56(16.37)**
Experience (trade count)	-0.0001(0.000)**	-0.0001(0.0000)***
*** p<.001, ** p<.01, * p<.05, .<.10		

Table 4. Model Results for Average Research Time per Trade

In both models the treatment is significant and the coefficient is negative. Consistent with our hypothesis 1, traders with multiple accounts spent less time researching per trade. The treatment effect size for model 1 is nine minutes (assuming no experience), accounting for most of the entire difference between treatment and control research times. For model 2 the effect size is six minutes. In both models the experience and treatment interaction coefficient are significant and negative, consistent with hypothesis 2, indicating that experience for those traders who create multiple accounts is of greater benefit with respect to research efficiency. The interaction term effect size is a half of a second saved for every accumulated trade for the treatment group, which translates over the course of the study period as four minutes by then end of the study for those traders who trade daily.

Diagnostics

As revealed by both an intraclass correlation test and an anova test between an intercept-only standard model and a mixed model, using the client as the random component in a mixed model is an appropriate choice for modeling the relationships.

While there is an active difference in opinion between using link functions (transforming the expected means) and transforming the data (e.g., Lindsey and Jones 1998; Lo and Andrews 2015; Packard 2014; Xiao, White, Hooten and Durham 2011), we find both return similar results.

Other diagnostic tests performed include multicollinearity (returning an acceptable variance inflation factors values below 2) and an omitted variable test for the GMM model (the null hypothesis of no omitted level-two effects is not rejected).

As p values are not considered entirely reliable for reporting mixed model results, we also performed an anova test between the model with and without treatment variable, which results in Chi-square value of 26.7 and p value of 0.00000023, results consistent with the mixed model findings.

Research Limitations, Alternatives, and Extensions

The data captured concerns the users' trading and research activities only as conducted with the brokerage platform. Our findings are valid to the degree that differences of trading and research activities conducted outside the brokerage platform are random across treatment and control or, if there are systematic differences, these differences are captured in the empirical self-selection corrections. A second limitation of this research is the premise that traders' intuitively or purposefully seek to conserve energy. This premise is grounded in decades of social science research but is only applicable to the degree that trading is perceived by the traders as "work." Some traders may trade as a hobby and prefer to spend more time researching relative to the "practical" trader. Our findings are valid to the degree that such traders are either a trivial proportion of traders overall or proportional across treatment and control types.

There are a number of possible alternative explanations for research time changes in addition to the organization of accounts. The nature of the individual trader – better organized, more intelligent, etc. – may be an appealing intuitive explanation for the self-separation into treatment and control and the source of differences. However, extant research regarding information processing and decision making suggests that individuals' cognitive style is statistically insignificant relative to contextual drivers (Vilar and Zumer 2008), a finding consistent with IS research regarding decision making support (Huber 1983). Still another intuitive alternative explanation for the creation of multiple accounts is to address practical matters – separating assets for legal matters or dividing assets for a purpose such as college savings. However, practical and personal motivations for the creation of subcollections are not in conflict with the proposed relationships – if the subcollection is thought of any differently than securities in other accounts (with respect to financial performance or financial goals), the information processing related to the subcollection is mediated through concepts.

Research extensions using distributed cognition as a referent theory for examining feature repurposing include further examination of the alignment of individuals' mental concepts with the organization of digital information. Kirsh (2010) offers a number of distributed cognition benefits made possible in part through organization such as the reification and entification of the concepts represented. As such, the actors' understanding of a concept may evolve in a different manner as the concepts come to possess

emergent properties allowing for more effective evaluation related to the actors' goals. An example in the present trading context is that the organization of securities into accounts specific to production rules may allow for more refined feedback which in turn evokes a more nuanced production rule. Through this refinement, the changing information supplied by the environment is also modified as "…what ultimately matters…is the way niche construction leads to new feedback cycles…" (Clark 2011, p. 62). For instance, in the current context a trader may wish to evaluate oil and gas security trading under the production rule that the price of oil and gas securities vary with changes in six-month crude oil futures. As time passes, the trader may find that altering the meaning of the "oil and gas" industry from one of company revenue to one of company production technologies better matches the anticipated relationship. The digital maintenance of such categories as cognitive "units of work" allows for a greater fluidity with respect to feedback cycles.

In contrast to developing refined categorizations of concepts, the organization of digital information may reduce the descriptive complexity of the environment in that the less relevant properties and the scope of the properties considered are diminished through the effective organization of information. Thus the organization of information supports more efficient decision-making through better control of the number of attributes (Jacoby 1977) and type of attributes (Ariely 2000) under consideration. Under both cases, this research can broadly be related to the IS post-adoptive system use literature (e.g., Jasperson et al. 2005; Ortiz de Guinea and Markus 2009) in identifying systematic, predictable, individual-level behaviors as informed by the referent theory of distributed cognition.

Practical Implications

Neurological research identifies the benefits to maintaining a single attention set by keeping similar tasks together (Levitin 2014). Given the exponential growth in information and the predominant use of IT to execute tasks, users should be expected to pursue approaches with IT such as feature repurposing to reduce their effort. However, it may also appear counterintuitive to explore feature repurposing from a normative perspective. Indeed, one might describe the predictable bypassing of the provided IS features simply as poor design. But such a conclusion frames design as an act that takes place before the IS is used, a perspective that may no longer be as valid as one that considers design as part of the user and IS relationship. It follows that the designers should track the users' acts of feature repurposing, particularly as it applies to the organization of digital information. Consider for instance account management as offered by Netflix. Netflix began offering the option for users to create multiple profiles. When Netflix later revoked this functionality, deeming it too complex, a small but vocal minority complained and Netflix reestablished this functionality (Norman 2011). Though no specific reason for the reversal was documented, and in fact the original intent of the designers was the support of multiple subscribers under a single account (Sandoval 2013), there is anecdotal evidence of the use of these multiple profiles by a single user for the organization of content,

> *Netflix lets you set up a maximum of five different logins on your account, and this typically lets you grant access to someone else in the family or means you can keep the kids' viewing history (and recommendations) separate from your own. However, even if you're the only person who uses your Netflix account, these extra user logins can still come in handy. Think about the basic principle behind them: They keep viewing history and viewing recommendations separate. As a result, you can have one login to indulge your love of action movies and one login to concentrate on those cerebral foreign detective dramas you're so fond of. More simply, you could use one account for films and one for television shows. It makes life easier when you're trying to find something you're halfway through (Nield 2015).*

This passage reinforces the idea of the blurring of the design and use distinction, with technically-adept users more inclined to "craft" the IS in ways that may not be counter to the design but are also not anticipated.

There are several practical implications arising from this research for the brokerage firm and financial trading systems in general. One first implication is simply to add explicit support for organizing subsets of securities. While some traders may have a single trading rule through which a single account affords sufficient management, some traders have yet to explore the creation of subsets, accepting the IS features as static. A second implication is to treat these subaccounts as "new" information and insight. For

instance, the brokerage firm could create "wisdom of the crowds" templates; that is, data mine the traders' emergent categories and make them available to other traders to adopt and adjust. The brokerage firm could provide information about these templates and report on their performances. The brokerage firm could even aggregate the templates into certain themes and create "virtual mutual funds" for investment (or shorting).

The research is meaningful to practice more generally in that, by identifying systematic user behaviors regarding IT artifact manipulation, developers will have a reliable guide to evaluate design not in terms of "more" features but rather in terms of the breadth of discretion provided to the user. Indeed, users' feature repurposing have been the source of inspiration for IS features. For instance, the use of the "@" symbol was first used casually among Twitter users to indicate a direct reply to a specific user. Twitter recognized a solution for an opportunity they had not yet attempted to address and formally began supporting the "@" symbol convention as a means to direct tweets (Seward 2013).

As observed by Garud et al. (2008), "Our observations highlight a pragmatic approach to design in which incompleteness is harnessed in a generative manner. This suggests a change in the meaning of the word 'design' itself — from one that separates the process of design from its outcome, to one that considers design as both the medium and outcome of action." This guidance can be better understood and thus further enhanced through a framework to understand these unanticipated actions. Distributed cognition is one such framework as established in this research. Our research contribution towards IS post-adoptive system is the use of the referent theory distributed cognition to propose that feature repurposing will be driven by the goal of conserving cognitive resources via the form of the purposeful organization of information.

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